

DEVELOPMENT OF A DIGITAL CAMERA TREE EVALUATION SYSTEM

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ABSTRACT

Within the Strategic Plan for Forest Inventory and Monitoring (USDA Forest Service 1998), there is a call to “conduct applied research in the use of [advanced technology] towards the end of increasing the operational efficiency and effectiveness of our program”. The digital camera tree evaluation system is part of that research, aimed at decreasing field time and increasing the informational value and reliability of field data. Our approach started with the use of a commercially available, non-metric digital camera for obtaining diameter and height measurements from individual stems. The lessons learned from these original attempts have shown that this concept is feasible, and helped to indicate specific areas needing improvement. Methodological improvements to be made include using convergent images and digital range information to account for tree lean and investigation into ways to address the faulty assumption of a circular (or elliptical) cross section. A completely new field-ready, durable, self contained instrument is being constructed that will digitally output image, 3 axis inclination, and range data; and compatible software is being developed to process this data and output information according to user requirements.

KEYWORDS

dendrometer, forest inventory, mensuration, digital camera, instrumentation

INTRODUCTION

The Digital Camera Tree Evaluation System is being developed: 1) to acquire more data in less time, 2) to extract more types of information {e.g., biomass, health indicators, defect}, and 3) to give foresters the ability to create volume tables applicable to their particular sample population. The system consists of a portable instrument that digitally records inclination in three axes, range, and image data; as well as the necessary software components to extract the desired information from these data.

Using a commercially available digital camera with analog range and single axis inclination, Clark et al. (1998a) reported a 6.9 percent inaccuracy for 54 diameter measurements at heights from 1.4 to 21 meters in leaf-on tests in the fall of 1997. Further testing after some methodological improvements yielded a maximum anticipated error of ± 4 cm (95% chi-square) on 241 diameter measurements at heights to 20 meters in a leaf-off test (Clark et al. 1998b). These studies have shown that this concept is feasible, and have helped to indicate specific areas needing improvement.

Methodological Improvements

Improvements in experimental methodology include marking measurement locations on the stem. This will allow us to explicitly evaluate height as well as diameter and reduce some extraneous sources of variability. Cross-sectional deviation from a regular geometric shape (circle, ellipse) can be partially accounted for by directional control, though this will add variation when comparing an instrument that measures convergent tangents (an optical fork) to and instrument that measures parallel tangents (calipers). Alternative statistics to paired measurements can be reported, or camera and caliper derived cross sectional areas may be compared with actual measured cross-sectional areas. The creation of algorithms utilizing convergent imagery to correct for tree lean resulting in the proper location and proper scaling of measurements is the most critical methodological improvement that needs to be made in this system.

Instrument Improvements

The creation of a hybrid instrument will combine the spectral and geometric strengths of a digital camera with the durability, range and orientation precision of a laser rangefinder. Processing algorithms will use data from these sensors to perform automated photogrammetric solutions that can deliver precise measurements without manual input. All sensors, including the camera lens interior orientation, will be calibrated.

Procedural Improvements

Massive amounts of raw data are no advantage to us if we still have to manually extract all of the desired information. The fields of close range photogrammetry and machine vision are making great strides in automated information extraction from digital images. Though most practical applications are industrial in nature under controlled lighting conditions, this technology is proceeding out-of-doors and into the forest. Our goal is to bring together and improve on these methods to process the raw data to the stage needed by the end user.

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